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STRIDE | Southeastern Transportation Research, Innovation, Development and Education Center

# Final Report

## Developing a New Course for Public Transportation Education

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## ABSTRACT

Safe, efficient, and accessible public transportation is a key component of livable and sustainable transportation systems. It is therefore critical that both undergraduate and graduate-level Civil Engineering students have a better understanding of the planning, design, and operation of public transportation systems so they can improve or support these systems when they enter the workforce. Unfortunately, this material is not readily available in most university curriculums. Therefore, the main goal of this project is to develop a set of public transportation course modules for both the Introduction to Transportation (an undergraduate senior course) and a stand-alone Transit Planning and Operations course (a specialized graduate course) that will be shared and evaluated at different universities. The modules were designed to be easily applied by instructors with limited experience in the transit industry and in conducting transit systems research. The process for designing the modules included researching applicable literature, reaching out and collaborating with educators and practitioners, and mind mapping the core concepts needed for transportation practice. The modules were implemented, assessed and revised based on student learning outcomes.

## BACKGROUND

Public transportation systems are recognized as a critical component in addressing urban and rural mobility challenges, including congestion, air quality, and accessibility. In fact, the USDOT, USHUD and USEPA's Partnership for Sustainable Communities listed "provide more transportation choices" as first among six livability principles to guide interagency coordination (ICF International 2010). The USEPA goes further to name "transit accessibility" and "transit productivity" as two of their twelve Sustainable Transportation Performance Measures (USEPA 2011). Surprisingly, despite this recognition among practitioners, most US engineering education programs do not emphasize the role of public transportation in urban transportation systems. Many graduates have little training in understanding how to increase transit accessibility and transit productively, two areas that are vastly affected by all practicing transportation professionals.

In addition, according to TCRP 77 *Managing Transit's Workforce in the New Millennium*, "the transit industry is experiencing an increasing number of workforce recruitment and retention challenges" (McGlothin Davis 2002). The report recognizes the need to expand a skilled workforce for transit planning and engineering positions by training the best and brightest coming out of university programs. This transit industry goal is in line with STRIDE's workforce development goals.

The Civil Engineering workforce is currently experiencing an increased need for professionals with strong backgrounds in public transportation systems as more rural and urban regions seek to develop transit systems to address congestion, emission, and mobility issues. Transit provides mobility to those who cannot or prefer not to drive, including access to jobs, education and medical services (American Public Transit Association 2008). In 2007, public transportation saved 646 million hours of travel delay and 398 million gallons of fuel in the U.S., resulting in a savings of $13.7 billion in congestion costs (Schrank and Lomax 2009). Use of public transportation reduced U.S. $CO_2$ emissions by 6.9 million metric tons in 2005 (Davis and Hale 2007). While hybrid and electric vehicle technologies can reduce the carbon-footprint of single-occupancy vehicles, they cannot compete with transit in reduction of traffic and promotion of compact, sustainable communities. As such, it is critical that both undergraduate and graduate-level Civil Engineering students have a better understanding of the planning, design, and operation of public transportation systems if we are to meet the livability needs of our growing communities.

There is wide recognition that transit should be a cornerstone of transportation education. A survey done by Turochy in 2004, for example, revealed that "mass transit" was ranked by practicing engineers as 14$^{th}$ on a list of 31 important transportation topics, having risen significantly since a similar survey was done in 1986 (Turochy 2006). With the increased awareness of transit's role in transportation sustainability and livability, the need for transit education may be even more prominent in student's minds today as well. Our younger generations are noticeably changing their transportation behavior and habits, and many are

seeking education and disciplines that foster their interest in livability and sustainability. In a study of American's driving habits, Frontier Group found that average person age 16 to 34 drove 23% less miles in 2009 than in 2001 (Davis, et al 2012). Based on the PI's own experience in graduate student recruitment, there is a hunger on the part of many students to better understand how to create a transportation system that is more efficient and effective at moving people and goods sustainably.

In June 2009, a group of educators from university transportation programs across the nation met to further develop and enhance the Introduction to Transportation course offered through most Civil Engineering programs. Conference attendees were tasked with collectively deciding the key concepts that should be covered in the introductory course (Beyerlein, et al 2010), of which transit was a recurring topic. Subsequent to the conference, several educators worked to develop learning outcomes and knowledge tables for the course (Bill, et al 2011). The knowledge table for transit and non-motorized transport includes:

- Public Transportation: Familiarity with system design, modes, and associated operating characteristics
- Modes: Bus, light rail, heavy rail, commuter rail, and paratransit
- System design: Radial vs linear systems, collector-distributor systems
- Capacity and level-of-service analysis
- Integration within larger transportation system: connectivity, access & mobility, transit-oriented design

Surprisingly, despite this renewed in interest in public transportation, our review of undergraduate Civil Engineering courses revealed very little material pertaining to transit planning, design and operations. Even in a survey of elective Transportation Planning courses, where transit planning should naturally be included, only 74% included "transit planning and management" as a course component (Zhou and Schweitzer 2009). Our own review also found that even fewer universities have a course specifically related to public transportation. The implication of this is that those students graduating in the coming years, who will be planning, designing and operating the transportation system for the next 40 years, most likely will not have an understanding of the role that transit plays in transportation systems. The resulting transportation system plans and designs that they create can hinder transit accessibility and productivity and have major implications for future ridership.

Perhaps a reason for this reduced presence of transit topics in transportation courses is the fact that relatively few comprehensive teaching materials exist for instructors on this topic. With many topics to cover in only one or two undergraduate courses and a short year-long masters degree program, there is limited time to cover any topic in transportation. Furthermore, instructors tend to rely on the materials from their own education and work experience. It is therefore difficult to change the direction of transportation curriculum. Without ready-made easy-to-use materials, concepts that fall outside of the normal repertoire are easily ignored.

University students enrolled in Civil Engineering at all levels need to have a better understanding of planning, design and operation of public transportation if we are to expect high quality transit projects to be planned, built and operated as needed by our communities. Graduating Civil Engineers often take positions that impact the effectiveness of public transportation. Engineers often work in planning roles for many levels of government to make decisions about future transit networks. Many graduates become city engineers who decide the feasibility of transit signal priority or exclusive transit lanes. Others may become developers, who decide how a development should be oriented, such as along a major street with easy transit access or with an immense parking lot between the transit service and the front door. Finally, many engineers work directly for transit agencies or the consultants they hire to design their systems.

Therefore, the objective of this project was to develop readily applied undergraduate and graduate course modules for educators, in the southeast and the nation as a whole, so that they might be able to improve the quantity and quality of public transportation material in their courses. These modules will be created based on the core concepts critical to public transportation, stemming from those identified in Beyerlein, et al 2010 and Bill, et al 2011.

## RESEARCH APPROACH

The main goal of this project was to develop effective and ready-to-be-applied undergraduate and graduate course modules for educators (in the southeast and nation as a whole) so that they might be able to improve the quantity and quality of the public transportation material in their courses.

Specifically, the research team accomplished the following objectives:

- Constructed university-level teaching modules covering the planning, design, and operation of public transportation systems, designed for use in a 1-week introductory course and in a 15-week in-depth course.
- Assessed and documented the effectiveness of each module in terms of student learning outcomes (SLOs).
- Revised modules based on results of multiple semesters of teaching the courses at multiple universities.
- Distributed modules and course materials through a website.

The following section outlines the four phases of work required for the successful creation and evaluation of these course modules: 1) Development of course modules, 2) Implementation of course modules, 3) Assessment of student learning outcomes, and 4) Revision and dissemination of course modules.

## COURSE MODULE DEVELOPMENT

### Outreach and Literature Review

This first task sought to synthesize the current technical and educational materials related to public transportation systems. Technical material reviewed included NCHRP reports, FTA handbooks, TRB Conference Proceedings, DOT manuals, and other guidebooks. Educational materials included textbooks, syllabi, and online course materials. The research team reached out to numerous US universities with civil engineering programs to discuss the current public transportation-related course materials. A special focus was made to reach out to many of the great educators in this area that are currently retiring to obtain materials and discuss critical elements of transit education. This complete university course outreach included the following individuals:

- Dr. Edward Beimborn, University of Wisconsin Milwaukee
- Dr. Robert Bertini, Portland State University
- Dr. Carlos Daganzo, University of California at Berkeley
- Dr. Anne Dunning, University of Kansas
- Dr. Kevin Heaslip, Utah State University
- Dr. Mark Hickman, University of Arizona
- Dr. Jill Hough, University of North Dakota and National Transit Curriculum
- Dr. Michael Kyte, University of Idaho
- Dr. Rachel Liu, New Jersey Science & Technology University
- Dr. Nick Lownes, University of Connecticut
- Dr. Randy Machemehl, University of Texas at Austin
- Dr. Michael Meyer, formerly of the Georgia Institute of Technology
- Dr. G Scott Rutherford, University of Washington
- Dr. Steven Polzin, University of South Florida
- Dr. Vukan Vuchic, University of Pennsylvania
- Dr. Nigel Wilson, Massachusetts Institute of Technology

In our review, we did find one program creating transit curriculum entitled the National Transit Curriculum Committee. The program is led by Dr. Jill Hough, Director of the Small Urban & Rural Transit Center at Upper Great Plains Transportation Institute, and Paul Larrousse, Director of the National Transit Institute. The goals of the program are similar to the effort described in this report, however that curriculum is more focused on the planning aspects of public transportation whereas this material incorporates much in the design and operation of transit systems. The materials are still being finalized, but an early version was provided to include in the evaluation in this project.

The syllabus topics for each of these courses are shown in Table 1 and have been condensed into common topics in Table 2. The textbooks available are shown in Table 3 and the textbooks and major readings used in each course are shown in Table 4.

**Table 1 – Public Transportation Course Topics by University and Professor**

| University | MIT | U. Wash | Georgia Tech |
|---|---|---|---|
| **Professor** | **Nigel Wilson** | **G Scott Rutherford** | **Michael Meyer** |
| **Syllabus Used** | **Spring 2012** | **Spring 2012** | **Multiple Years** |
| **1** | Introduction to Public Transportation Planning | Class Overview | Introduction, Current Environment, Terms, Tech |
| **2** | Alternative Services and Modes | Transit in Seattle Region | Policy and Planning, Market Analysis, Land Use |
| **3** | Introduction to Cyclic Operations (Recitation) | National Transit Picture | Network Design |
| **4** | Cost Characteristics | BRT: Ways and Stations | Costs |
| **5** | Organizational Models and Contract Structure | BRT: Vehicles, Info, Benefits | Data Collection |
| **6** | Service Standards and Performance Measurement | BRT: Branding, Land Use | Route Level Analysis, Vehicle Size, Service Frequency, Operations Planning |
| **7** | Service Planning Process | *Meeting With Madison St. Advisors* | Facility and Terminal Design |
| **8** | Data Collection: Needs, Techniques, and Sampling | Bus Speed and Reliability | System Level Analysis, Alternatives Analysis, Impact, Travel Forecasting |
| **9** | Data Analysis and Inference | Link Light Rail | Land Use and Finance |
| **10** | Data Analysis and Inference | *Field Trip to Portland* | |
| **11** | Cost Modeling | Light Rail Transit | |
| **12** | Ridership Forecasting | Travel Demand Management | |
| **13** | Performance of a Single Route | Transit Alternatives Analysis | |
| **14** | Fare Policy and Technology | Metro Transit Planning | |
| **15** | Macro Models for Transit Design | Washington State Ferries | |
| **16** | Frequency Determination | *Field Trip to Vancouver B.C.* | |
| **17** | Vehicle Scheduling | Pedestrian & Bicycle Access | |
| **18** | Crew Scheduling | | |
| **19** | Automated Scheduling Methods | | |
| **20** | High Ridership Corridor Strategies | | |
| **21** | Network and Route Structure | | |
| **22** | Service Reliability and Operations Control | | |
| **23** | Bus Priority Systems) | | |
| **24** | Marketing | | |
| **25** | Workforce Planning | | |
| **26** | Labor Relations and Wrap-Up | | |

**Table 1 – Public Transportation Course Topics by University and Professor (continued)**

| University | U. Kansas | U. Conn | U. Arizona |
|---|---|---|---|
| **Professor** | **Anne Dunning** | **Nicholas Lownes** | **Mark Hickman** |
| **Syllabus Used** | **Spring 2012** | **Spring 2012** | **Fall 2010** |
| **1** | Introduction | Intro/Public Transport Networks | History of public transit in the US and current conditions |
| **2** | History, Legislation and Regulation | Institutional Context for Network Plan | Transit demand characteristics |
| **3** | Heavy Rail and Commuter Rail (Modes) | Network Structure Design | Costs, economic considerations, and financing alternatives |
| **4** | Light Rail and Streetcars (Modes) | Network Structure Design | Current management and planning issues |
| **5** | Bus Rapid Transit and City Bus (Modes) | Network Structure Design | Operations characteristics |
| **6** | Remand Reponses, Rural, and Small Town Transit (Modes) | *CTTransit Field Trip* | Transit modes, capacity and productivity |
| **7** | Transit and Land Use (Planning) | Assessing Network Design Solutions | Performance measurement and data collection methods |
| **8** | Transit Organizational Structures (Planning) | Assessing Network Design Solutions | Operations management, priority and control systems |
| **9** | Transit Finance at Metropolitan, State and Federal Levels (Planning) | Transit Station Location | Fixed-route and demand-responsive service design |
| **10** | International Transit (Planning) | Transit Station Location | Fixed-route frequency determination; timetabling |
| **11** | Right-of-way Design and Route Planning (Planning) | Operations Research Techniques | Vehicle and crew scheduling |
| **12** | Mode Selection, Vehicle Design, and Alternative Fuels (Design) | Operations Research Techniques | Demand-responsive service planning |
| **13** | Demographics, Equity, and Rider Choice (Planning) | Transit Network Design | |
| **14** | Community Value and Public Transit (Planning) | *Bridgeport Field Trip* | |
| **15** | Intelligent Transportation Systems (Planning) | Transit Network Design | |
| **16** | Workforce Scheduling (Operations) | Transit Network Design | |
| **17** | Performance Monitoring (Operations) | Transit Assignment | |
| **18** | Contracting (Operations) | | |
| **19** | Multimodal Transit (Multimodal Systems) | | |
| **20** | Future Considerations and Course Conclusion | | |

**Table 1 – Public Transportation Course Topics by University and Professor (continued)**

| University | U. Penn | NJ S&T | UT Austin |
|---|---|---|---|
| Professor | Vukan Vuchic | Rachel Liu | Randy Machemehl |
| Syllabus Used | Fall 2005 | Fall 2011 | Spring 2011 |
| 1 | History of Cities | Introduction | Introduction, Demand Estimation, Statistical Tools |
| 2 | Urban Passenger Transport Modes | Historical Development (Urban Growth) | Estimating Transit Demand |
| 3 | Vehicle Motion - Traction Systems and Performance | Historical Development (Transit Development) | Route Design |
| 4 | Travel Time Computations | Historical Development (Trends) | Basic Vehicle Scheduling |
| 5 | Capacity, Productivity, Efficiency of Transit Modes | Systems and Technologies (Modes) | Driver Scheduling |
| 6 | Highway/Road Transit Modes: Char. and Vehicles | Systems and Technologies (Components) | Networks |
| 7 | Highway Transit Modes: Way, Terminals, Ops | Policy and Planning (Land Use) | Rail Transit Summary |
| 8 | Rail Transit Modes: Characteristics and Vehicles | Policy and Planning (Environmental Impact) | Propulsion Systems |
| 9 | Rail Transit Modes: Way, Stations and Ops | Policy and Planning (Travel Demand) | Paratransit Concepts |
| 10 | Unconventional System/Tech Modes Concepts | Policy and Planning (Service Supply) | Evaluation |
| 11 | Specialized Modes and Technologies | Design and Engineering (Network) | |
| 12 | Paratransit | Design and Engineering (Facility) | |
| 13 | Characteristics and Comparisons of Transit Modes | Design and Engineering (Vehicles) | |
| 14 | Case Studies | Design and Engineering (Communications) | |
| 15 | | Operation and Management (Organization) | |
| 16 | | Operation and Management (Staffing) | |
| 17 | | Operation and Management (Financing) | |
| 18 | | Operation and Management (Marketing) | |
| 19 | | Operation and Management (Services) | |
| 20 | | System Evaluation (Cost Estimate) | |
| 21 | | System Evaluation (Performance Evaluation) | |
| 22 | | System Evaluation (Benefit/Cost Comparison) | |
| 23 | | Outlook of Mass Transportation (Society Need) | |
| 24 | | Outlook (Changing Travel Behavior) | |
| 25 | | Outlook (More Accurate Pricing) | |
| 26 | | Outlook (Improved Technology) | |

**Table 1 – Public Transportation Course Topics by University and Professor (continued)**

| University | Utah State | UW Milwaukee | UC Berkeley | U. Idaho |
|---|---|---|---|---|
| **Professor** | **Kevin Heaslip** | **Edward Beimborn** | **Carlos Daganzo** | **Mike Kyte** |
| **Syllabus Used** | **Fall** | **Online** | **2010** | **2011** |
| **1** | Introduction | Introduction | Planning—General Ideas & Transit Planning | Service Planning and Scheduling |
| **2** | Routes and Schedules | Background | Planning—Shuttle Systems | Service Planning and Scheduling |
| **3** | Routes and Schedules | Transit Planning, Major Investments and New Starts | Planning—Corridors | Quality of Service Analysis |
| **4** | Routes and Schedules | Analysis Procedures for Major Investment and New Starts | Planning—Two Dimensional Systems | Quality of Service Analysis |
| **5** | Routes and Schedules | Transit Planning for Operations | Planning—Flexible Transit (Dial-a-ride) | Transit Capacity |
| **6** | Quality of Service | Transit Route Location and Analysis | Management—Vehicle Fleets | Transit Capacity Examination |
| **7** | Capacity of Stops and Stations | Analysis Procedures for Transit Operations | Management—Staffing | Design Work and Analysis |
| **8** | Capacity of Stops and Stations | Project: The Belle Crisis (Service Cuts & Fare Hikes) | Reliable Transit Operations | Design Work and Analysis |
| **9** | Capacity of Stops and Stations | | | Design Work and Analysis |
| **10** | LRT & Bus Station Capacity | | | Design Work and Analysis |
| **11** | LRT & Bus Station Capacity | | | Meeting with Director of UI Parking and Transportation Services |
| **12** | LRT & Bus Station Capacity | | | Meeting with Moscow City Supervisor, Director of Development |
| **13** | LRT Design | | | Meeting with Moscow Public Works Director |
| **14** | LRT Design | | | Meeting with Pullman Transit |
| **15** | LRT Design | | | |

**Table 1 – Public Transportation Course Topics by University and Professor (continued)**

| University | Portland State | U. South Florida | N. Dakota | National Transit Curriculum Project |
|---|---|---|---|---|
| **Professor** | **Robert Bertini** | **Steven Polzin** | **Jill Hough** | **Jill Hough and Paul Larrousse** |
| **Syllabus Used** | **2007** | **Fall 2011** | **Spring 2012** | **-** |
| **1** | Introduction | Introduction | History and Business | Introduction |
| **2** | Technology Overview | History of Public Transit | Governance, Funding and ADA | Governance, Finance and Policy |
| **3** | Quality of Service Concepts | Travel Behavior | Social Change and Justice, Sustainability and Livability | Planning and Design |
| **4** | System Planning, Administration, Design Issues (Term Project) | Travel Behavior | Travel Behavior, Modal Characteristics | Management |
| **5** | Measuring Quality of Service | Modes and Technology | Network and Corridor Planning | Public Transit Trends |
| **6** | Transit Service | Modes and Technology | TOD, Land Use | |
| **7** | Capacity Concepts | Service Planning | Service Planning | |
| **8** | Transit Operations Principles | Service Planning | Human Service, Rural, Marketing | |
| **9** | Bus Facility Capacity | Transportation and Land Use | Management, Stakeholders | |
| **10** | Speed Concepts, Ridership and QOS | Organization and Administration | Performance Measurement, Labor, Ethical Challenges | |
| **11** | Transit Operations and Management | Costs and Productivity | Trends in New Paradigms and Business Models | |
| **12** | Stop, Station and Terminal Capacity | Strategic, Financial, System Planning | Trends in Technology, Impacts | |
| **13** | Bus Facility Design | Paratransit and TDM | Future of Transit | |
| **14** | Bus Rapid Transit Service Planning | Future of Public Transportation | | |
| **15** | Rail System Design | | | |
| **16** | Paratransit and Advanced Public Transportation Systems | | | |
| **17** | Rail Transit Capacity | | | |

## Table 2 - Common Topics by Public Transportation Course

| | | MIT | U. Wash | Northeastern | Georgia Tech | U. Kansas | U. Conn | U. Penn | Austin | Utah St. | UW Milwaukee | UC Berkeley | Portland State | N Dakota |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Topic** | | Wilson | Rutherford | Furth | Meyer | Dunning | Lownes | Vuchic | Machemehl | Heaslip | Beimborn | Daganzo | Bertini | Hough |
| **Rail Transit** | Summary/ Recognition | x | x | x | x | x | x | x | x | x | x | | x | x |
| | Route Design | x | x | | x | | x | x | x | x | x | | x | x |
| | Scheduling | x | | | x | | x | x | x | x | | | x | x |
| | Station Design | | | | x | | x | x | x | x | x | | x | |
| **Bus Transit** | Summary/ Recognition | x | x | x | x | x | x | x | x | x | x | x | x | x |
| | Route Design | x | x | x | x | x | x | x | x | x | x | x | x | x |
| | Scheduling | x | x | x | x | x | x | x | x | x | x | x | x | x |
| | Stop Design | x | x | x | x | x | x | x | x | x | x | x | x | |
| **Paratransit** | Summary/ Recognition | x | | | x | x | | x | x | | x | x | x | x |
| | Route Design | | | | | x | | | x | | x | x | | x |
| | Scheduling | | | | | x | | x | x | | x | x | | |
| **Pedestrians / Cyclists** | Summary/ Recognition | | x | | x | | x | | | | x | | | x |
| | Sidewalk Design | | x | | x | | | | | | | | | x |
| | Intersection Design | | x | | | | | | | | | | | |
| | Regulations | | | | | | | | | | | | | |
| **Data** | Conducting Surveys | x | | x | | | | | | | | | x | |
| | Data Management | x | | x | x | | | | | | x | | | x |
| **Planning Process** | General Planning Process | | | | x | | | | | | x | x | x | x |
| | Transportation Decision Making | | | | x | | | | | | x | | | x |
| | Forecasting Travel Demand | x | x | x | x | | x | | x | x | x | x | x | x |
| | Evaluating Alternatives | x | x | | x | x | | x | x | | x | | x | x |
| | Transport System Management | x | x | x | x | x | | | x | | x | | x | x |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Legal and Policy** | Legislation and Lawmaking | | | x | x | x | | | | | x | | | x |
| | Fare Structuring and Policies | x | x | x | x | x | | | | | | | x | |
| | Governmental Land Use Policies | | x | | x | x | | | | | x | | | x |
| | Environmental Impact Policies | | x | | x | x | | | | | x | | | x |
| **Finance** | Financing Public Transportation | | x | x | x | x | | | | | x | | x | x |
| | Funding, Finance, Grants | | x | x | x | x | | | | | x | | x | x |
| | Bidding/Contracts | x | | | | x | | | | | | | | |
| **Management** | Organization/ Institution Concepts | | x | x | x | x | | x | | | | | x | x |
| | Management/ Labor Organization | x | | | | x | | | x | | x | x | x | x |
| **Others** | Public Transport Safety/ Security | | x | x | x | | | | | | | | x | x |
| | Coordinating Transport Systems | x | x | | x | x | | | | | x | | | x |
| | Technology/ Vehicle Design | x | x | | x | x | x | x | x | | x | | x | x |
| | Marketing | | x | | x | | | | | | x | | | x |
| **Instruction Techniques** | Outreach/ Field Trips/ Speakers | | x | | | | x | x | | | | | x | x |
| | Class Project | | | | | | x | | x | | x | x | x | x |

Courses not included for lack of sufficient information: U Arizona, NJ S&T, Idaho, USF

## Table 3 - Textbooks Available in Public Transportation

| Title | Author | Year | Website featuring the book |
|---|---|---|---|
| *Urban Transit Operations, Planning and Economics* | Vukan Vuchic | 2005 | http://www.wiley.com/WileyCDA/WileyTitle/productCd-0471632651.html |
| *Urban Transit Systems and Technology* | Vukan Vuchic | 2007 | http://www.wiley.com/WileyCDA/WileyTitle/productCd-047175823X.html |
| *Public Transit Planning And Operation: Theory, Modelling and Practice* | Avishai Ceder | 2007 | http://www.amazon.com/Public-Transit-Planning-Operation-Modeling/dp/0750661666 |
| *Better Public Transit Systems: Analyzing Investments and Performance* | Eric Bruun | 2007 | http://www.amazon.com/Better-Public-Transit-Systems-Investments/dp/193236448X |
| *Public Transport: Its Planning, Management and Operation* | Peter White | 2008 | http://www.amazon.com/Public-Transport-Management-Operation-Environment/dp/0415445302 |
| *Advanced Modeling for Transit Operations and Service Planning* | W.H.K. Lam & M.G.H. Bell | 2002 | http://www.amazon.com/Advanced-Modeling-Transit-Operations-Planning/dp/0080442064 |
| *Managing Public Transit Strategically: A Comprehensive Approach to Strengthening Service and Monitoring Performance* | Gordon Fielding | 1987 | http://www.amazon.com/Managing-Public-Transit-Strategically-Comprehensive/dp/1555420680 |
| *The Transit Metropolis: A Global Inquiry* | Robert Cervero | 1998 | http://www.amazon.com/The-Transit-Metropolis-Global-Inquiry/dp/1559635916 |
| *Human Transit* | Jarrett Walker | 2011 | http://www.humantransit.org/human-transit-the-book-table-of-contents.html |
| *My Kind of Transit: Rethinking Public Transportation* | Darrin Nordahl | 2009 | http://www.amazon.com/My-Kind-Transit-Rethinking-Transportation/dp/1930066880 |
| *Public Transportation Systems: Basic Principles of System Design, Operations Planning and Real-Time Control* | Carlos Daganzo | 2010 | http://www.ce.berkeley.edu/~daganzo/Public/publication/Public%20Transportation%20Systems%20Book%20UCB-ITS-CN-2010-1.pdf (This is not a published book, but a very thorough compilation of his class notes.) |
| *Urban Public Transportation Systems: Implementing Efficient Urban Transit Systems and Enhancing Transit Usage* | Edited by Murthy Bondada | 2000 | http://www.asce.org/Product.aspx?ID=2147486962&ProductID=5144 |
| *Public Transportation* | George Gray & Lester Hoel | 1992 | http://ideas.repec.org/a/eee/transa/v27y1993i5p413-415.html |
| *Marketing Urban Mass Transit* | Lewis Schneider | 1965 | http://books.google.com/books/about/Marketing_urban_mass_transit.html?id=LC9PAAAAMAAJ |
| *The New Transit Town* | Hank Dittmar & Gloria Ohland | 2004 | http://www.amazon.com/New-Transit-Town-Transit-Oriented-Development/dp/1559631171 |
| *Urban Transportation Systems: Choices for Communities* | Grava | 2002 | http://www.amazon.com/Urban-Transportation-Systems-Sigurd-Grava/dp/0071384170 |

**Table 4 - Use of Textbook among Public Transportation Courses**

| University | Professor | Books & Readings |
|---|---|---|
| Massachusetts Institute of Technology | Nigel Wilson | None Required; Recommended: TCQSM, APTA Fact Book (2011), Ceder (2007), Vuchic (2005), Bruun (2007); Many Supplementary Readings |
| University of Washington | G Scott Rutherford | Vuchic (2005) |
| Northeastern University | Peter Furth | His own draft textbook; lots of supplementary papers |
| Georgia Tech (Former) | Michael Meyer | TCRP Reports (Dozens of them) |
| University of Kansas | Anne Dunning | Vuchic (2005) & Dittmar (2004) |
| University of Connecticut | Nicholas Lownes | Required: HiTrans. (2006) HiTrans Best practice guide; Recommended: Vuchic (2005), Vuchic (2007) and Grava (2002) |
| University of Arizona | Mark Hickman | Vuchic (2005), TCQSM, Vuchi (2007), Ceder (2007), Fielding (1987), Berchmann (1993), Cudahy et al (1990), Lam (2003) |
| University of Pennsylvania | Vukan Vuchic | Vuchic books |
| New Jersey Science & Technology University | Rongfang (Rachel) Liu | Gray and Hoel (1992) |
| University of Texas at Austin | Dr. Randy Machemehl | Grava (2002) |
| Utah State University | Kevin Heaslip | Vuchic (2005), TCQSM, TCRP Report 30 (Scheduling) |
| University of Wisconsin at Milwaukee | Edward A. Beimborn | His own notes |
| University of California at Berkeley | Carlos Daganzo | His own booklet |
| University of Idaho | Mike Kyte | TCQSM |
| Portland State University | Robert Bertini | TCQSM, TCRP Report 88 Performance Measurement, APTA Factbook, and Supplement readings |
| University of South Florida | Steven Polzin | Vuchic (2005) |
| North Dakota State University | Jill Hough | Course notes |

**Interviews with Transit Practitioners**

Perhaps the most important resource in determining public transportation system course content is practitioners, as they are most aware of what knowledge is needed for daily practice. As such, a survey of practitioners in the transit industry was conducted using multiple choice and open-ended questions about knowledge/ skills required in practice. Respondents included transit agency staff, metropolitan planning organization personnel, city government employees, and transportation consultants, representing a range of organization sizes and US regions. The results show an interesting split between a need for technical skills and management knowledge (e.g. access, politics, and management). Additionally, public meetings and community involvement were identified as topics that many respondents "wished" they had learned about previously.

60 practitioners were contacted for the survey and 21 responses were received. Of these, 13 were from transit agencies, 4 were consultants, 2 were state DOT employees, and 2 were city employees. The majority of responses were from professionals in the southeast US.

In the first question, practitioners were asked "Which of the following *public transportation / transit system* topics are critical for professionals in your organization to know?" Responses are shown in Table 5.

**Table 5 – Practitioner Ranking of Critical Topics in Public Transportation**

| Topic | Votes |
|---|---|
| Planning | 20 |
| Operations | 18 |
| Public Communication | 16 |
| Finance | 15 |
| Safety | 14 |
| Scheduling | 14 |
| Design | 12 |
| Management/Labor | 10 |
| *Other:* | |
| Customer Service | 3 |
| Economics | 2 |
| Community Demographics | 1 |
| Public/Private Partnerships | 1 |
| Data Collection Systems | 1 |
| Technical Analysis | 1 |
| New Technology/Equipment | 1 |
| FTA Regulations | 1 |
| Grant Management | 1 |
| Construction | 1 |
| Right of Way | 1 |
| Funding | 1 |

In the second through fourth questions, practitioners were asked "When hiring new employees, how important is a candidate's understanding of the following *DESIGN / PLANNING / OPERATIONS* topics?" Responses are shown for design in Table 6, planning in Table 7 and operations in Table 8.

**Table 6 – Practitioner Ranking of Design Topics in Public Transportation**

| Topic | | (1) Unimp-ortant | (2) Somewhat Unimportant | (3) No Opinion | (4) Somewhat Important | (5) Important | (0) Not Applicable | Weight Value | Avg |
|---|---|---|---|---|---|---|---|---|---|
| **Rail Transit** | Route Design | | 2 | 3 | 8 | 5 | 3 | 70 | 68.7 |
| | Scheduling | 1 | 1 | 4 | 8 | 4 | 3 | 67 | |
| | Station Design | | 2 | 2 | 6 | 7 | 4 | 69 | |
| **Bus Transit** | Route Design | | 1 | 1 | 11 | 8 | | 89 | 88.3 |
| | Scheduling | 1 | 0 | 2 | 11 | 7 | | 86 | |
| | Stop Design | | 1 | 1 | 10 | 9 | | 90 | |
| **Paratransit** | Route Design | 3 | | 5 | 5 | 4 | 4 | 58 | 63.5 |
| | Scheduling | 3 | | 4 | 6 | 6 | 2 | 69 | |
| **Pedestrians** | Sidewalk Design | | 2 | | 9 | 10 | | 90 | 88.7 |
| | Intersection Design | | 2 | | 7 | 11 | 1 | 87 | |
| | Regulations | | | 3 | 10 | 8 | | 89 | |
| **Cyclists** | Facility Design | | 1 | 1 | 8 | 10 | 1 | 87 | 87.0 |
| | Intersection Design | | 2 | | 7 | 11 | 1 | 87 | |

**Table 7 – Practitioner Ranking of Planning Topics in Public Transportation**

| Topic | (1) Unimp-ortant | (2) Somewhat Unimportant | (3) No Opinion | (4) Somewhat Important | (5) Important | (0) Not Applicable | Weight Value |
|---|---|---|---|---|---|---|---|
| General Planning Process | | | | 3 | 18 | | 102 |
| Conducting Surveys | | 2 | 1 | 15 | 3 | | 82 |
| Forecasting Travel Demand | | 1 | | 16 | 4 | | 86 |
| Evaluating Alternatives | | | | 3 | 18 | | 102 |
| Transportation Decision Making | | | | 4 | 17 | | 101 |
| Transportation Data Management | | 1 | 1 | 10 | 9 | | 90 |
| Transport System Management | | | 3 | 11 | 7 | | 88 |
| Organization/ Institution Concepts | 1 | 2 | 1 | 8 | 9 | | 85 |

**Table 8 – Practitioner Ranking of Operations Topics in Public Transportation**

| Topic | (1) Un-important | (2) Somewhat Unimportant | (3) No Opinion | (4) Somewhat Important | (5) Impo-rtant | (0) Not Applicable | Weight Value |
|---|---|---|---|---|---|---|---|
| Management/ Labor Org | 1 | 4 | 2 | 8 | 5 | 1 | 72 |
| Public Transport Safety/ Security | | | | 16 | 5 | | 89 |
| Fare Structuring and Policies | | 3 | 3 | 10 | 5 | | 80 |
| Governmental Land Use Policies | | 4 | | 6 | 8 | 3 | 72 |
| Environmental Impact Policies | | 2 | | 8 | 8 | 2 | 76 |
| Financing Public Transportation | | 4 | | 6 | 11 | | 87 |
| Coordinating Transport Systems | | | 1 | 8 | 12 | | 95 |
| Funding, Finance, Grants | | 1 | 2 | 7 | 11 | | 91 |
| Legislation and Lawmaking | | 5 | 2 | 6 | 6 | 2 | 70 |
| Bidding/Contracts | | 2 | 1 | 10 | 8 | | 87 |

Practitioners were then asked "Which of the following technical skills / software are critical for professionals in your organization to know?" Responses are shown in Table 9.

**Table 9 - Critical Software for Public Transportation**

| Topic | Votes |
|---|---|
| Excel/ Microsoft Office | 21 |
| ArcGIS | 13 |
| RouteMatch/ Trapeze | 9 |
| Microstation/ AutoCAD | 8 |
| VisSim/ VisSum | 4 |
| SAS/ JPSS/ JMP/ Mintab | 3 |
| TransCAD/ CUBE | 3 |
| Visual Basic/ C++/ Java | 1 |

Practitioners were then asked "Does your organization provide public transportation training for entry-level engineers/planners?" Of the respondents, 8 did provide training and 13 did not. The specific training mentioned included:

- Apprenticeship
- BRT Workshop

- Company Training Course
- Continuing Education
- Management of Transit Construction Projects
- Ongoing Training and Seminars
- On the Job Training
- Project Management Essentials
- Sponsored FTA Courses
- Transit Planning Training

When asked "Do you have any favorite materials (i.e. books, journals, blogs) related to public transport you would recommend to others?", practitioners provided the following list of materials:

- American Public Transportation Association (APTA) - Reports
- Center of Transit-Oriented Development (CTOD) - Reports
- Conference of Minority Transportation Officials (COMTO) – Conference Proceedings/Reports
- Federal Transit Administration (FTA) - Reports
- Mass Transit - Magazine
- National Transit Institute (NTI) - Courses
- Progressive Railroading - Magazine
- Trafficware University - Courses
- Transportation Research Board (TRB) - Conference Proceedings/Reports
- Transportation Cooperative Research Program (TCRP) - Reports
- Urban Transit: Operations, Planning, Economics by Vukan Vuchic - Book
- Urban Transit Systems and Technology by Vukan Vuchic - Book
- Urbanrail.net - Reports
- Women's Transportation Seminar (WTS) – Conference Proceedings/Reports

Finally, practitioners were asked (in an open-ended question) if there is anything that new public transportation engineers/planners in their organization require excessive training on; what knowledge/ skills they wish all colleagues knew that would make their job easier/ more efficient; and if there is anything about public transportation/ transit systems that they wish they had learned more about in their education. Responses fell into three areas, communication, technical skills and legislation / funding:

1. <u>Communication</u>

- Politics/ Social Aspects of Public Transportation
- Ability to Write/ Policy Writing
- Contract Management
- Patience
- Public Administration/ Public Meetings/ Community Involvement
- Public Speaking/ Presentations
- Conflict Resolution Skills
- Coordination Skills

- Customer Service
- Project Management

2. Technical Skills

- Modeling Software
- Planning – Routing, Scheduling, Forecasting, Coordinating with Land Use
- Understanding Operations/ Operation Skills
- Critical Thinking
- Economic Analysis of Project Proposals
- GIS
- Performance Management
- Tradeoff Analysis Between Modes
- Travel Demand Forecasting
- Quality Control

3. Legislation/ Funding

- Federal/ FTA Regulations, New Legislation
- Grant Management
- Labor Negotiations
- Transportation Finance
- Funding
- Understanding Partnerships
- Understanding Public Transit Benefits

### Mind Mapping of Core Transit Concepts

Using the information collected in university outreach and transportation practitioner interviews and survey, we then established a list of the core concepts of public transportation systems that should be covered in any curriculum via a mind mapping exercise (see Figure 1). Each item in the list was then ranked based on relative importance and whether it should be included in shorter modules. This ranking resulted in a final set of measurable student learning outcomes that describe the key take-away skills and knowledge that all students should gain from these course modules. The translation from the core topics to the SLO is shown in Table 9. The SLO include:

1. Describe the evolution, benefits, and challenges of different transit modes
2. Collect, by-hand or from existing sources, data to measure transit performance
3. Quantify changes in capacity and reliability caused by changes in ITS and right-of-way
4. Quantify route-level transit service characteristics
5. Schedule vehicles and crews to maximize transit productivity
6. Select a set of transit routes that meets the needs of the ridership
7. Explain how station and local neighborhood design influence accessibility
8. Identify long-term planning alternatives and evaluate them using a benefit-cost analysis
9. Outline the factors influencing transit ridership and predict demand for service in a region
10. Identify and calculate fare/ technology and transit performance measures
11. Outline the different opportunities for/ challenges of managing a transit system
12. Discuss the future of transit technology and the role of traveler information

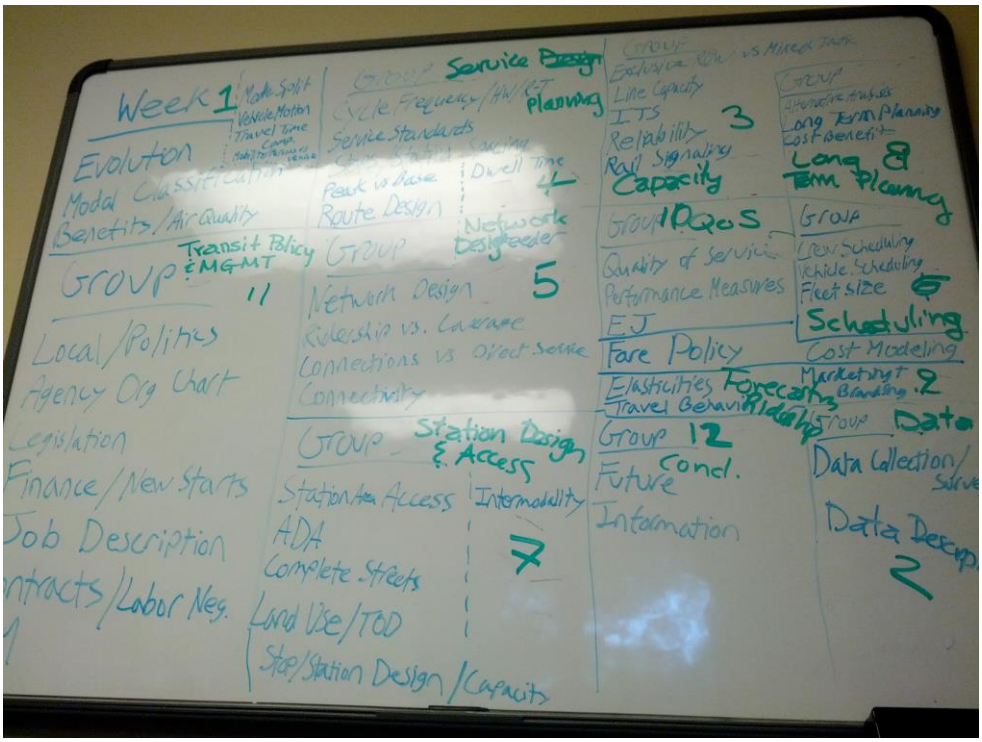


**Figure 1 - White Board Showing Results of Mind Mapping Exercise**

**Table 10 - Translation from Topics to SLO**

| Module | Theme | Lecture | Topics (from Mind Mapping) |
|---|---|---|---|
| 1 | Context for Making Transit Decisions | The Evolution of Transit Systems | Evolution, Benefit/ Challenges |
| | | Comparing Transit Modes | Mode Split, Vehicle Motion, Modal Classification |
| | | Decision-making Characteristics | Travel Time Composition, Person vs. Vehicle Mobility |
| 2 | Describing Transit Systems with Data | Transit System Data | Mode and Region Data Types & Sources |
| | | Person-trip Data | Rider and Trip Data Types & Sources |
| | | Collecting Surveys | Collection and Surveys |
| 3 | Measuring and Maximizing Capacity | Choosing Between ROW and Mixed Traffic | Exclusive ROW versus Mixed traffic, line capacity |
| | | Intelligent Transit Systems | ITS, Reliability |
| | | Rail Signals | Rail Signals |
| 4 | Service Planning and Design | Service Standards | Service Standards, Peak vs. Base |
| | | Cycle Design | Cycle Frequency/ HW/ R-T, Dwell Time |
| | | Spacing Design | Stops/ Station Spacing |
| 5 | Transit Network Optimization and Design | Balancing Ridership & Coverage | Ridership vs. Coverage |
| | | Balancing Connections & Direct Service | Connections vs. Direct Service, Connectivity |
| | | Optimization Techniques | Network Design |
| 6 | Staff and Fleet Scheduling | Crew Scheduling | Crew Scheduling |
| | | Vehicle Scheduling | Vehicle Scheduling |
| | | Fleet Size Optimization | Fleet Size |
| 7 | Station Design and Access | Complete Streets | Stop design and capacity, complete streets |
| | | Surrounding Development | Land use/ TOD |
| | | Access & Intermodality | Intermodality, station access and ADA |

| | | | |
|---|---|---|---|
| 8 | Long Term Transit Planning | The Planning Process and Products | Long term planning |
| | | Alternative Analyses | Alternative Analysis, cost/benefit analysis |
| 9 | Forecasting Transit Ridership | Travel Behavior | Travel Behavior |
| | | Models & Elasticities | Models & Elasticities |
| | | Marketing and Branding | Marketing and Branding |
| 10 | Measuring & Improving Transit Quality of Service | The Role of Quality of Service | Quality of Service, Environmental Justice |
| | | Performance Measures | Performance Measures |
| | | Dealing with Fares | Fare Policy, Cost Modeling |
| 11 | Transit Policy and Management | GUEST LECTURE | Local Politics, Agency Org Chart, project management, job descriptions |
| | | Legislation and Funding Constraints | Legislation, Finance/ New Starts |
| | | Contracts and Labor Negotiations | Contracts and labor negotiations |
| 12 | The Future of Transit Systems | New Types of Information Sharing | New Types of Information |
| | | Future Technologies | Future Technologies |

## COURSE MODULE IMPLEMENTATION AND ASSESSMENT

Using the list of core concepts and SLO to guide the topics, and materials from the literature review and university outreach to provide content, complete course materials were prepared. The materials included readings, lecture presentations, discussion guidance notes, assignments, and suggested topics for projects and guest lecturers. Specifically, public transport modules for two unique courses were created: a week-long series in an upper-level undergraduate course (e.g. Introduction to Transportation) and a complete semester-long graduate course (e.g. Transit Planning and Operations). The modules are designed to be easily applied by instructors with limited experience in the transit industry, and individual modules can be incorporated into existing courses as needed. The undergraduate course materials include three shortcourse modules, readings and assignments covering:

- Selecting Between Transit Modes
- Improving Transit Service through Planning, Design & Operations
- Group Application Exercise

The graduate course materials include 20 semester course modules, readings, class activities, and assignments covering:

- Describing Transit Systems with Data
- Measuring and Maximizing Capacity
- Service Planning & Network Design
- Staff & Fleet Scheduling
- Station Design & Access
- Long Term Transit Planning
- Forecasting & Encouraging Ridership
- Measuring & Improving Transit Quality
- Transit Policy & Management

Upon completion of the course materials, we made use of them in our own courses at Georgia Tech and Auburn University to educate students and to assess the SLO. In addition, the materials were distributed to several instructors willing to include the module materials in their courses. Instructors included:

- Rod Turochy, Auburn University;
- Michael Hunter and Tom Wall, Georgia Tech;
- Nicholas Lownes, University of Connecticut;
- Alison Conway, City College of New York;
- Brian Lee, University of Vermont;
- Wesley Marshall, University of Colorado;
- John Miller, VDOT;
- Rhonda Young, University of Wyoming; and
- Larry Suave, University of Washington.

These university faculty members were selected to represent a variety of regions, student populations, and experience. For example, some professors have prior experience teaching transit planning, whereas others do not. We provided support for volunteer instructors to answer questions and assist in preparing classes, as needed. Instructors provided feedback as to which materials should be revised for content based on lack of student understanding.

Based on the results from the SLO assessments, the modules were revised so they are more effective at providing consistent student learning as well as include the core topics identified by practitioners and instructors. The final materials are all included in hard copy as an appendix to this report and on the STRIDE website.

Additionally, these materials may be applied in a variety of education disciplines, including other engineering fields, policy and social sciences, regional planning and others. Table 11 highlights which topics would be most suitable for other education fields.

**Table 11 – Module Application Fields**

| Module Topic | Civil Engineering | Other Engineering Disciplines | Policy & Social Sciences | Environmental Science | Architecture & Community Planning | Technology Development | Operations Research |
|---|---|---|---|---|---|---|---|
| *Describing Transit Systems with Data* | x | | x | | | | |
| *Measuring and Maximizing Capacity* | x | | | | | x | |
| *Service Planning & Network Design* | x | | x | | x | | |
| *Staff & Fleet Scheduling* | x | | | | | | x |
| *Station Design & Access* | x | x | | x | | x | |
| *Long Term Transit Planning* | x | | x | x | x | | |
| *Forecasting & Encouraging Ridership* | x | | | | | | x |
| *Measuring & Improving Transit Quality* | x | x | x | x | x | x | |
| *Transit Policy & Management* | x | | x | | x | | x |

## CONCLUSIONS, RECOMMENDATIONS AND SUGGESTED FUTURE RESEARCH

The main goal of this project was to develop effective and ready-to-be-applied undergraduate and graduate course modules for educators (in the southeast and nation as a whole) so that they might be able to improve the quantity and quality of the public transportation material in their courses. The modules were designed based on a process of researching applicable literature, reaching out and collaborating with educators and practitioners, and mind mapping the core concepts needed for transportation practice. The modules were then implemented, assessed, and revised based on student learning outcomes. Finally, the modules are being disseminated through the STRIDE website at http://www.stride.ce.ufl.edu/public-transportation-course-modules.

A few strategic decisions were made regarding the materials. First, given a parallel project by Dr. Jill Hough to produce transit course materials with more of a planning focus, we focused these materials on operations and design with smaller planning elements. Second, we decided to make use of Transit Cooperative Research Program reports and other online materials to limit the cost to students. In addition, the very inexpensive and accessible text by Jarrett Walker entitled "Human Transit" was used to supplement these materials. It is of note that excellent textbooks by Vukan Vuchic and Avishai Cedar exist that could form the basis of a course if an alternative approach is taken in which the course is based more thoroughly on one textbook.

The final course modules were designed to be easily incorporated into existing courses in the Civil Engineering curriculum. A course on travel demand modeling could utilize the travel demand models module. A course on transportation policy could utilize the regulation & finance module. A course on optimization could utilize the service frequency determination module. Finally, a course on data analysis could utilize the data types & sources and data collection modules. Many of the modules could supplement planning curriculum as well.

The materials prepared for this project have already formed the basis for courses at Georgia Institute of Technology, Auburn University, University of Wyoming, City College of New York, and Virginia Tech. In the future, it is the intent of the researchers involved to continue to refine the materials created to keep them consistent with the latest innovations in public transportation. In addition, the materials will be periodically assessed by reaching out to the universities that have adopted them. We hope to improve the ability of Civil Engineering students to understand and work with issues in public transportation. A more livable and sustainable transportation system cannot be achieved without common industry knowledge of how transportation planning, design and operations impact transit accessibility and productivity.

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